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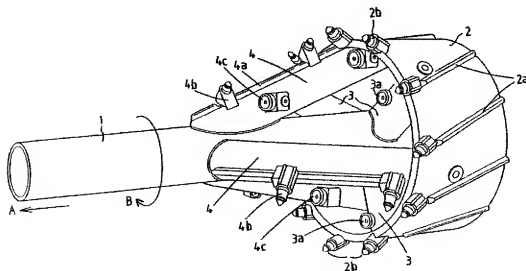
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(54) Title: BACK REAMER



(57) Abstract: A back reamer for underground bores, more particularly for use in directional horizontal drilling. The back reamer comprises a head with a cylindrical wall which is attached, by means of struts, to a central tube and is provided, at one end, with soil loosening means and with spraying nozzles for a drilling liquid, whilst the ends of the central tube are provided with means for coupling the tube to a drill string. At least some of the struts are arranged according to the surface of a cone, the apex of which points into the direction of travel of the reamer.

BACK REAMER

The invention relates to a back reamer for underground bores, more particularly for use in directional horizontal drilling, comprising

5 a head with a cylindrical wall which is attached, by means of struts, on a central tube and is provided, at one end, with soil loosening means and nozzles for a drilling liquid, whilst the ends of the central tube are provided with means for coupling the tube to a drill string.

This type of back reamer, called "flyer" in expert circles, is well-known and is used to enlarge a bore of a relatively small diameter (also called "pilot bore") that is made by bringing a drill string into the underground according to the principle of directional horizontal drilling. To that end the back reamer is attached with one central tube end to an end of the drill string that extends beyond the bore just made and is then pulled - while rotating and supplying drilling fluid - through the underground by means of the retracting drill string. While being pulled through the rotating back reamer wall loosens soil particles around the pre-drilled bore, which soil particles get mixed with drilling fluid and are discharged behind the reamer through the expanded bore. While pulling the reamer through the underground a second drill string, that is connected to the trailing end of the central tube, may be pulled along. The second drill string may, in a next phase, serve as a pulling string, e.g. when a further expansion of the bore is desired.

25 The well-known reamer under consideration, with which all of the struts are positioned in a plane that is perpendicular to the axis of the reamer and located behind the active front end face of the cylindrical wall, does not operate in a satisfying manner in various types of soil. So it often occurs that large pieces of soil simply move between the struts rearwards and cause clogging, so that the soil discharge in the rearward direction may stagnate. To reduce this risk relatively large amounts of drilling fluid, such as

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is often insufficient. Therefore the expansion of an underground bore by means of this type of back reamer has to be effected in a number of steps by using back reamers of increasing diameters. Consequently, working with the well-known back reamer is generally time consuming, whilst relatively large amounts of drilling fluid are required.

Now the invention aims at providing an improved back reamer by means of which a pre-drilled bore may be enlarged to the desired diameter in a few steps, while avoiding the disadvantages above referred to.

Accordingly a back reamer of the type above referred to is characterized in that at least some of the struts are arranged according to the surface of a cone, the apex of which points in the direction of travel of the reamer.

When using the reamer of the present invention the soil to be loosened around the pre-drilled bore will be treated by the struts positioned according to a conical surface more uniformly, viz. from the centre obliquely outwardly and rearwardly, so that the soil will be effectively "crumbled". Working with the reamer of the present invention goes substantially faster and requires a substantially smaller amount of drilling fluid. This applies for all types of soil, in which the directional horizontal drilling technique can be applied.

It is to be remarked that a cone-shaped reamer is already known. This well-known reamer, however, comprises a conical body of sheet metal, on the outer surface of which ribs and spraying nozzles are provided, whilst slots are provided in the outer surface, through which a soil/drilling fluid mixture has to discharge in the rearward direction. With this well-known reamer relatively low speeds can be realized. With higher travelling speeds the conical reamer body will, e.g. in a clayey soil, get blocked up with loosened soil rather quickly, due to which the discharge in the rearward direction stagnates and the reamer tends to rotate idly and compress the soil in the travelling direction.

Furthermore US 5,687,805 discloses a back reamer that has a pyramid-shaped body, the apex portion of which is adapted to be coupled to the trailing end of a pulling pipe string. The pyramid-shaped reamer is closed at its trailing end by a circular plate of a diameter that corresponds with the diameter of the enlarged bore. In

operation drilling fluid is passed through the pulling pipe string rearwardly into the hollow space of the pyramid-shaped body and from the latter through openings in the pyramid side walls into the surrounding soil. In this case the desired bore enlargement is effected by compacting the soil radially outwardly rather than by loosening amounts of soil and discharging the same either in the rearward or forward direction.

In a preferred embodiment of the invention at least part of the struts arranged according to a conical surface is provided, on the side facing in the direction of rotation, with nozzles for spraying a drilling fluid, the spraying openings of which are substantially directed in the direction of travel of the reamer.

Advantageously the struts arranged according to the surface of a cone are in the form of tube sections which constitute the hydraulic connection between the central tube and the spraying nozzles.

A particular embodiment of the back reamer of the present invention is characterized by a detachable end wall that may block the outlet of the cylindrical wall at the rear end thereof. By placing such an end wall the back reamer of the present invention may also function as a guide body for pulling e.g. a pipeline through the expanded underground bore. When the reamer is functioning as a guide body the end wall attached to it will prevent the drilling fluid, that is supplied through the spraying nozzles, from flowing unrestrictedly in the rearward direction towards the pipeline to be pulled through and will force said fluid to effectively drain off into the pulling direction.

Preferably the detachable end wall is provided with recesses along its circumference, each of said recesses forming a discharge opening for an adjacent spraying nozzle provided on the inner side of the end wall, with its spraying opening directed rearwardly. By means of these rearwardly directed spraying nozzles an effective "lubrification" of the wall of the expanded bore behind the reamer body may be obtained, which facilitates the pulling through of the pipeline.

The present invention will hereinafter be further explained by way of example with reference to the drawing.

Fig. 1 is a perspective front view of the back reamer according to the present invention, with the back wall removed and

fig. 2 is a perspective rear view of the back reamer of fig. 1, with the back wall mounted in place.

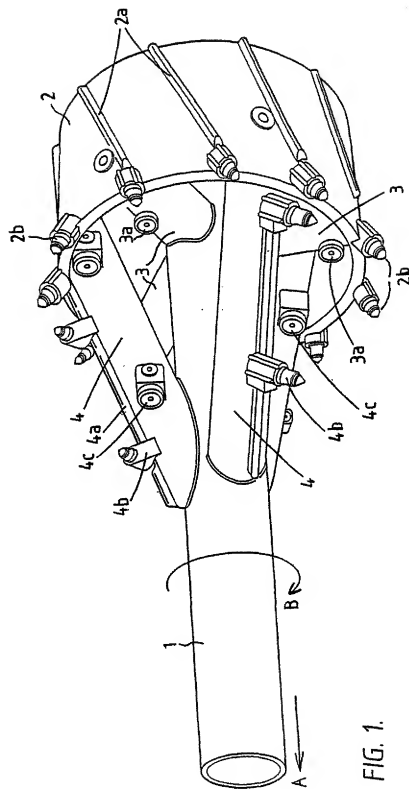
5 The backreamer illustrated in the drawing comprises a central tube 1 and a cylindrical wall 2 positioned coaxially thereabout.

Three radially directed connecting struts 3 extend between the central tube 1 and the wall 2.

10 Ribs 2a are provided on the outer surface of the wall 2 and thorn-shaped elements 2b are provided on the front edge of the wall. In use, when a cylindrical soil body that surrounds the pre-drilled bore have to be removed, the ribs and thorn-shaped elements effect the loosening of said soil body from the soil that remains untouched by the back reamer.

15 On the front side of the struts 3 nozzles 3a are provided, which direct into the travelling direction and are designed for spraying a liquid, such as bentonite, with which the loosened soil has to be mixed to form a muddy substance that can be discharged in the rearward direction. The struts 3 are therefore in the form of
20 tube sections, the hollow spaces of which are in communication with the central tube 1, which also functions as a supply tube for drilling fluid. Moreover the struts 3 may be provided with thorn-shaped elements, which are similar to the elements on the front and edge of the wall 2.

25 So far the described reamer is of a well-known structure. According to the invention a second group of struts 4 is provided in addition to the three radially directed struts 3. The three struts 4 of the second group are arranged according to a conical surface, the apex of which points into the travelling direction A. Struts 4 are,
30 for the greater part, located in front of the front edge of the cylindrical wall 2 and are positioned circumferentially offset relative to the struts 3 such that each strut 4 extends in the middle between two adjacent struts 3. The struts 4 are also in the form of tube sections, of which the hollow spaces are in communication with
35 the central tube. On the outer side of the struts 4 longitudinal ribs 4a are provided, as well as thorn-shaped elements 4b which are directed obliquely both in the rotary direction B and the travelling direction A. Spraying nozzles 4c are provided on those sides of the



struts 4 that are facing into the rotary direction; the spraying openings of the latter nozzles are substantially directed into the travelling direction A.

Reference is now made to fig. 2, in which is shown how the cylindrical wall 2 can be closed on the rear side by an end wall 5 to be fastened by means of bolts 5a. The radially directed struts 3 serve as a support for the end wall 5. To this end threaded bushings (not shown in the drawing) are welded onto the rear side of the struts 3 for receiving the bolts 5a. At six locations distributed along the circumference of the end wall recesses are provided. Three of these recesses, which are designated at 5b, nearly serve as an adaptation to the struts 4, which end at the respective locations, whilst the other three recesses, which are designated at 5c, function as passage openings for the spraying jets, which may emerge from spraying nozzles 3c that are provided behind the recesses 5c. The spraying nozzles 3b, 4c and 3c above referred to can be closed either individually or in groups, depending on the conditions under which the reamer must operate.

To prepare the reamer for normal use, i.e. when a pre-drilled bore has to be enlarged, the end wall 5 is removed, so that soil that is loosened in front of the reamer and is then mixed with drilling fluid, will be allowed to escape to the rear and discharged through the bore section that has already been enlarged. To put the reamer into normal use, the reamer is coupled with the front open end of the central tube 1 (to the left in fig. 1) to the end of the drilling string, that extends beyond the (pilot) bore that has just been drilled, whilst the closed rear end of the central tube is coupled to an "idle" drilling string, which is pulled along with the reamer into the enlarging bore and may, in a later stage, also function as a pulling string.

C L A I M S

1. A back reamer for underground bores more particularly for use in directional horizontal drilling, comprising

5 a head with a cylindrical wall which is attached, by means of struts, on a central tube and is provided, at one end, with soil loosening means and nozzles for a drilling liquid, whilst the ends of the central tube are provided with means for coupling the tube to a drill string, characterized in that at least some of the struts are
10 arranged according to the surface of a cone, the apex of which points in the direction of travel of the reamer.

2. A back reamer according to claim 1, characterized in that at least part of the struts arranged according to a conical surface is provided, on the side facing in the direction of rotation, with
15 nozzles for spraying a drilling fluid.

3. A back reamer according to claim 2, characterized in that the spraying openings of the spraying nozzles are substantially directed into the travelling direction of the reamer.

4. A back reamer according to claims 2-3, characterized in that
20 the struts arranged according to the surface of a cone are in the form of tube sections which constitute the hydraulic connection between the central tube and the spraying nozzles.

5. A back reamer according to claim 4, characterized in that the tube sections are provided with ribs.

6. A back reamer according to claims 1-5, characterized by an detachable end wall that may substantially close the outlet of the cylindrical wall at the rear end thereof.

7. A back reamer according to claim 7, characterized in that a number of struts is positioned in a plane perpendicular to the axis
30 of the reamer, said plane being located adjacent the rearward edge of the cylindrical wall, said struts functioning as a mounting support for the removable end wall.

8. A back reamer according to claims 6 and 7, characterized in that the removable end wall is provided with recesses at a number of
35 locations along the circumference of the end wall, said recesses constituting a passage opening for adjacent spraying nozzles which are positioned behind the end wall and have their spraying openings directed rearwardly.

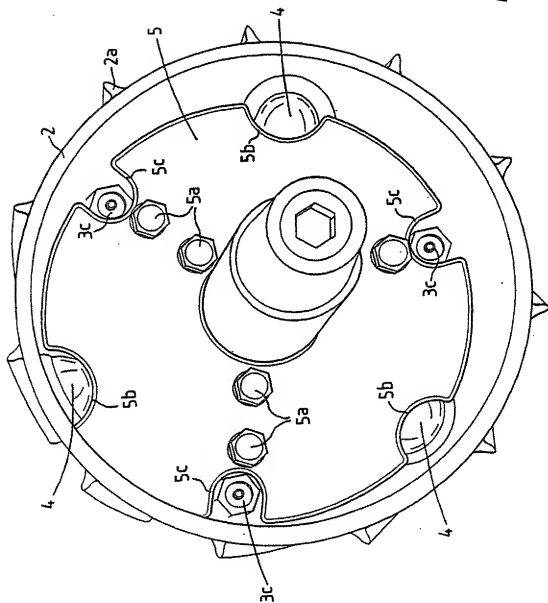


FIG. 2.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/NL 01/00258A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B10/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 687 805 A (PERRY ROBERT G) 18 November 1997 (1997-11-18) the whole document	1
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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